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ABSTRACT

Selection of items for analogy tests according to the Rasch item probability of "goodness of fit" to the model is compared with three commonly used item selection criteria: item discrimination, item difficulty, and item-ability correlation. Word, picture, symbol and number analogies in multiple choice format were administered to several hundred college students. Analysis showed that Rasch item probabilities of .05 and .01 are more lenient (in terms of proportion of items rejected) criteria than commonly used criteria (item difficulty of between .10 and .80, item discrimination of .20, item-ability correlation of .20). Results also showed only a moderate amount of overlap among the four criteria, with the Rasch item probability and item discrimination being the most similar, and item difficulty and item-ability correlates being the most dissimilar. (Author)

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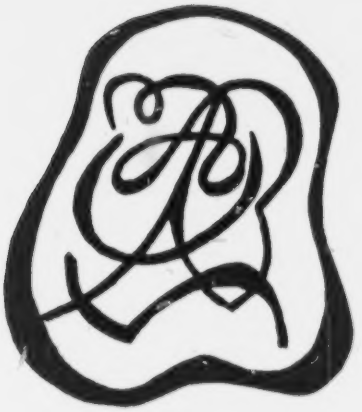

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Selection of items for analogy tests according to the Rasch item probability of "goodness of fit" to the model is compared with three commonly used item selection criteria: item discrimination, item difficulty, and item-ability correlation. Word, picture, symbol and number analogies in multiple-choice format were administered to several hundred college students. Analysis showed that Rasch item probabilities of .05 and .01 are more lenient (in terms of proportion of items rejected) criteria than commonly used criteria (item difficulty of between .20 and .80, item discrimination of .20, item ability correlation of .20). Results also showed only a moderate amount of overlap among the four criteria, with the Rasch item probability and item discrimination being the most similar, and item difficulty and item-ability correlates being the most dissimilar.

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Analogy tests						

A Comparison of the Rasch Item Probability with Three Common Item Characteristics as Criteria for Item Selection

Howard E. A. Tinsley and Rene' V. Dawis

Rasch (1960, 1966) proposed a simple logistic model for ability and achievement tests involving two parameters -- a person parameter pertaining to the person's ability, and an item parameter pertaining to the difficulty of the measurement. Rasch's model allows the separation of, and independent estimation of, these two parameters. Since the item parameter can be estimated in a manner that does not depend on the ability level of the sample of persons used in the estimation, Rasch's procedure has been characterized as sample-free (Wright and Panchapakesan, 1969).

As described by Wright and Panchapakesan (1969) the Rasch procedure consists of two stages, item calibration and person measurement. Item calibration consists of estimating the item parameters and their standard errors from the responses of a large sample of persons to the set of items. Items which do not satisfy the criterion of "fit" to the model are eliminated. The remaining "good-fitting" items are then used to obtain test scores for the persons in the sample. From these scores and the difficulties (or, conversely, easinesses) of the items used, an estimate of each person's ability and the standard error of this estimate are obtained.

The present study concerns the selection of items for analogy tests according to the Rasch procedure's "goodness-of-fit" test, and how this selection compares with item selection based on three commonly used item characteristics, namely, item discrimination, item difficulty and item-ability correlation.

Method

Instruments -- Five analogy tests were utilized in the study: one form each for word, picture and symbol analogies and two number analogy forms. There were 94 items in the word analogy test, 32 items in the symbol analogy test, 99 items in the picture analogy test, and 178 number-analogy items, 93 in one form and 35 in the other. All items were of the multiple choice type, with five response alternatives and with the blank in the item stem occurring in any of the four positions of the analogy elements (i.e., in A, B, C or D position in the analogy A:B::C:D). All tests were introduced by one standard page of test instructions.

Subjects -- The subjects in the study were college students enrolled in an introductory psychology class at the University of Minnesota during the fall of 1970. All subjects were volunteers (obtained through the subject pool of the Department of Psychology) who were participating in the research to gain additional points toward their course grade. Each student completed one, two or three tests. A total of 1,400 tests were completed, including 304 word analogy tests, 319 picture analogy tests, 301 symbol analogy tests, and 268 of one form and 208 of the other form of the number analogy test.

Administration -- Because the test forms were designed to be self-explanatory, subjects were simply given the test, instructed to read the directions and complete the test. The test administrator was always available, however, to answer any questions. Each subject was allowed to complete one, two, or three tests. Tests were administered in the following order: 1) word, 2) picture, 3) symbol, 4) number, form 1, and 5) number, form 2. No time limits were set for completion of the tests.

Analysis -- Item analysis was performed using the Bart et al. (1970) adaptation of the Wright and Panchapakesan (1970) computer program. This

program outputs, for each item, the item difficulty (proportion of correct responses), the Rasch item easiness estimate and its error term, the item-ability correlation, the item discrimination, and the Rasch probability value for the "goodness of fit" test. Of interest to this study are item difficulty, item-ability correlation, item discrimination and the Rasch item probability (of "fit" to the model).

The Rasch item probability is the probability of the observed response pattern given the hypothesis that the item fits the Rasch simple logistic model. According to Wright (1970) the problem of item fit is "not simple". The P-value is the probability of a chi square value derived by summing squared normal deviate values across score groups (with df = number of score groups minus 1). The normal deviates values, in turn, are normal deviate transformations of "proportion correct" values for each score group. Thus, a normal deviate of 2 or less is considered acceptable while values greater than 3 are unacceptable. With acceptable normal deviates, the P-value of the resulting chi square can range below .001, hence cut-off points of .05 (as recommended by Brooks, 1964) or even of .01 (as recommended by Anderson, et al., 1968) may be overly stringent. The number of persons in each score group is another factor, since a misfit based on a small (less than 10) group is less significant than one based on a large (greater than 20) group. Nonetheless, for this study, Rasch item probability cutoffs of .01, .05, .10, .25, .50, and .75 were specified as the minimum acceptable criterion values.

Using item difficulty as a selection criterion is justified on the grounds that item variance is a function of item difficulty, and it is desirable to select the items with the largest variances since test variance is a function of the summed item variances (Lord and Novick, 1968, Ch. 15).

Item variance is at its greatest for item difficulty at p = .5 and decreases as p deviates from .5. Three criterion levels for item selection were used in this study: $.20 \leq p \leq .30$, $.30 \leq p \leq .70$, and $.40 \leq p \leq .60$.

Item-ability correlation is the point biserial correlation of item scores with ability scores and is an index of item validity (Lord and Novick, 1968, Ch. 15). For this study, two levels were used as criteria for item selection: $r_{pb} \geq .20$ and $r_{pb} \geq .30$.

Item discrimination is an index derived from the biserial correlation between latent ability and scores on the item according to the formula (Lord and Novick, 1968, p. 378).

$$d = r_b / \sqrt{1 - r_b^2}$$

where d = discrimination index

r_b = biserial correlation between item score and latent ability.

Birnbaum (in Lord and Novick, 1968, p. 474) states that .93 and .20 represent the extremes of the range of item discrimination values encountered in practice. Three levels of item discrimination values were used in this study as criteria for item selection: $d \geq .20$, $\geq .30$, and $\geq .40$.

The above criteria for item selection were compared with respect to the percentage of items in each test that met each criterion (i.e., each level of each type of criterion). Since, in practice, item selection is usually based on more than one criterion, the percentage of items meeting two criteria was examined for every pair of criteria. Of major interest was the percentage of those items meeting the Rasch item probability criteria which also met other criteria.

Results

Table 1 shows the percentages of items for each type of analogy test

that satisfied the various criteria. As might be expected, the proportion of items selected depended on both the type of criterion and the type of analogy test. The largest percentages of items were consistently selected for number analogies when the Rasch item probability, item discrimination, or item-ability correlation, was employed as the selection criterion. For item difficulty as the criterion, the highest selection rate was observed for word analogies. The lowest percentages of items selected were consistently for picture analogies when the Rasch item probability or item-ability correlation was used as the criterion. The lowest selection rates tended to be for symbol analogies when using item discrimination as the criterion, and for number analogies when using item difficulty as the criterion. A Rasch item probability of .01 was the most lenient criterion among those tried out in this study, regardless of type of analogy item. In terms of percentages of items selected, an item discrimination level of .20 was approximately equivalent to a Rasch item probability of .05, while an item difficulty range of .20 to .80 was approximately equivalent to a Rasch item probability of .25. This was generally true for the four different types of analogy items. However, an item-ability correlation of .20 was approximately equivalent to a Rasch item probability of .25 for word analogies, .35 for symbol and picture analogies, and .10 for number analogies.

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Insert Table 1 here
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Tables 2, 3, 4, and 5 show the percentages of items satisfying both of each pair of criteria, for word, symbol, picture, and number analogies, respectively. Table 2 shows that for word analogies, and for the Rasch item probability paired with other criteria, the most lenient levels used in this study selected between 56% and 78%. For other pairs of criteria, the

selection rates for the most lenient levels ranged between 33% and 59%. Similar percentage rates were observed for symbol analogies (Table 3) and picture analogies (Table 4). For number analogies, as shown in Table 5, the percentage rates for the pairings of Rasch item probability with other criteria, both at the most lenient levels, ranged from 40% to 90%. Pairings of the other criteria resulted in selection rates at the most lenient levels that ranged from 32% to 80%. These percentage rates for paired criteria provide some idea of the overlap (or lack of overlap) between the criteria. In terms of percentage of items selected in common, the Rasch item probability and item discrimination tended to be most similar, while item difficulty and item-ability correlation tended to be most dissimilar. In both instances, the supportive results were uniformly found across all four types of analogy items.

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Insert Tables 2, 3, 4, and 5 here
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Conclusion

In this study, the Rasch item probability (an index of "goodness of fit" of the item to the Rasch simple logistic model) was compared with three other item characteristics -- item difficulty, item-ability correlation, and item discrimination -- as criteria for item selection. The results of this study show that Rasch item probability levels of .01 and .05 proposed as criteria for item selection are more lenient (in terms of proportion of items rejected) than commonly used levels of the other item characteristics (to wit, item difficulty of between .20 and .80, and item-ability correlation and item discrimination of .20 or greater). This finding was true for all four types of analogy items used: word, symbol, picture and number. The results also showed only a moderate amount of overlap among the four criteria, with the

Rasch item probability and item discrimination being the most similar, and item difficulty and item-ability correlation being the most dissimilar, criteria for item selection.

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Table 1

Percentage of Items Satisfying Four Item Selection Criteria, by Type of Analogy Test

Criterion	Type of Analogy Test			
	Word 94 Items	Symbol 82 Items	Picture 99 Items	Number 178 Items
Rasch Item Probability				
.01	94	95	92	96
.05	86	84	83	88
.10	78	78	75	82
.25	60	61	52	66
.50	32	33	27	48
.75	11	13	10	27
Discrimination				
.20	81	70	76	92
.30	62	50	58	83
.40	50	44	29	74
Difficulty				
.20 - .80	74	56	65	42
.30 - .70	59	34	43	30
.40 - .60	36	20	22	14
Item-Ability Correlation				
.20	56	45	37	80
.30	23	11	07	53

Table 2

Percentage of 94 Word Analogy Items
Satisfying Pairs of Item Selection Criteria

Criterion	Discrimination			Difficulty			Item-Ability Correlation	
	.20	.30	.40	.20-.30	.30-.70	.40-.60	.20	.30
Rasch Item Probability								
.01	78	62	49	69	52	30	56	22
.05	73	60	47	65	50	29	53	21
.10	66	53	41	59	45	27	48	20
.25	50	40	31	47	35	19	36	15
.50	26	20	16	26	18	08	18	09
.75	09	06	05	07	04	01	06	03
Item-Ability Correlation								
.20	56	56	50	33	23	18		
.30	23	23	23	18	13	07		
Difficulty								
.20 - .80	59	47	38					
.30 - .70	46	34	28					
.40 - .60	27	19	15					

Table 3

Percentage of 32 Symbol Analogy Items Satisfying Pairs of Item Selection Criteria

Criterion	Discrimination			Difficulty			Item-Ability Correlation	
	.20	.30	.40	.20-.30	.30-.70	.40-.60	.20	.30
Rasch Item Probability								
.01	70	50	44	56	37	18	45	11
.05	63	49	44	49	33	18	45	11
.10	61	43	43	46	32	18	44	10
.25	51	41	38	34	24	17	39	09
.50	27	21	18	18	15	11	20	04
.75	11	07	06	07	05	04	07	00
Item-Ability Correlation								
.20	45	45	44	34	28	15		
.30	11	11	11	07	06	05		
Difficulty								
.20 - .80	43	34	32					
.30 - .70	33	28	26					
.40 - .60	17	16	16					

Table 4

Percentage of 99 Picture Analogy Items Satisfying Pairs of Item Selection Criteria

Criterion	Discrimination			Difficulty			Item-Ability Correlation	
	.20	.30	.40	.20-.80	.30-.70	.40-.60	.20	.30
Rasch Item Probability								
.01	76	58	28	62	40	20	46	07
.05	69	53	25	54	35	17	42	04
.10	62	50	23	48	30	14	40	04
.25	43	36	18	35	21	08	27	03
.50	21	18	06	17	11	05	12	00
.75	08	06	02	06	04	03	03	00
Item-Ability Correlation								
.20	47	47	27	34	21	09		
.30	07	07	07	06	04	02		
Difficulty								
.20 - .80	53	40	20					
.30 - .70	34	25	12					
.40 - .60	15	10	05					

Table 5

Percentage of 178 Number Analogy Items Satisfying Pairs of Item Selection Criteria

Criterion	Discrimination			Difficulty			Item-Ability Correlation	
	.20	.30	.40	.20-.80	.30-.70	.40-.60	.20	.30
Rasch Item Probability								
.01	90	82	73	40	29	13	79	53
.05	83	76	68	36	27	13	74	51
.10	78	73	64	34	26	12	71	48
.25	63	60	52	25	18	09	58	42
.50	46	44	41	14	09	05	43	33
.75	26	25	24	08	06	03	25	18
Item-Ability Correlation								
.20	80	80	74	32	24	11		
.30	53	53	53	18	14	07		
Difficulty								
.20 - .80	39	30	29					
.30 - .70	29	25	21					
.40 - .60	12	11	10					

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